

## CLAIMS

1. A figure reading apparatus for reading, recognizing and outputting a figure, the figure reading apparatus comprising:

image input means for inputting a color image;

5 main color extraction means for extracting main colors contained in the color image and resolving the color image into main color images respectively of the main colors extracted from the input color image;

projection means for projecting points of extracted main colors on a three-dimensional space onto a plane by using a conversion expression;

10 candidate narrowing down means for removing combinations that need not be combined according to features of distance between main colors projected onto a two-dimensional space; and

combination generation means for combining images from candidates narrowed down and generating an image area candidate.

15 2. The figure reading apparatus according to claim 1, wherein the projection means projects points of extracted main colors on the three-dimensional space onto a plane of  $R + G + B = 0$  from a direction of  $(R, G, B) = (1, 1, 1)$  according to the following conversion expression by using a projection technique.

20 [Equation 2]

$$\begin{pmatrix} x & y & z & 1 \end{pmatrix} = \begin{pmatrix} x' & y' & z' & 1 \end{pmatrix} \begin{pmatrix} \cos(-\frac{\pi}{4}) & 0 & -\sin(-\frac{\pi}{4}) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-\frac{\pi}{4}) & 0 & \cos(-\frac{\pi}{4}) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta_1 & \sin\theta_1 & 0 \\ 0 & -\sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\cos\theta_1 = \frac{\sqrt{2}}{\sqrt{3}}, \sin\theta_1 = \frac{1}{\sqrt{3}}$$

3. The figure reading apparatus according to claim 1, wherein the projection means finds a projection plane perpendicular to a change

direction of color information other than a direction of  $(R, G, B) = (1, 1, 1)$  according to a feature of a light source, and projects points of extracted main colors onto the projection plane.

4. The figure reading apparatus according to claim 2 or 3, wherein  
5 the candidate narrowing down means compares distances between points of main colors on the found projection plane,

if a distance is within a predetermined threshold range, then the candidate narrowing down means regards the combination of the main colors as valid, and

10 if a distance is outside the predetermined threshold range, then the candidate narrowing down means regards the combination of the main colors as invalid.

5. A figure reading method for reading, recognizing and outputting a figure, the figure reading method comprising:

15 an image input step of inputting a color image;

a main color extraction step of extracting main colors contained in the color image and resolving the color image into main color images respectively of the main colors extracted from the input color image;

20 a projection step of projecting points of extracted main colors on a three-dimensional space onto a plane by using a conversion expression;

a candidate narrowing down step of removing combinations that need not be combined according to features of distance between main colors projected onto a two-dimensional space; and

25 a combination generation step of combining images from candidates narrowed down and generating an image area candidate.

6. The figure reading method according to claim 5, wherein at the projection step, points of extracted main colors on the three-dimensional

space are projected onto a plane of  $R + G + B = 0$  from a direction of  $(R, G, B) = (1, 1, 1)$  according to the following conversion expression by using a projection technique.

[Equation 3]

$$\begin{pmatrix} x & y & z & 1 \end{pmatrix} = \begin{pmatrix} x' & y' & z' & 1 \end{pmatrix} \begin{pmatrix} \cos(-\frac{\pi}{4}) & 0 & -\sin(-\frac{\pi}{4}) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-\frac{\pi}{4}) & 0 & \cos(-\frac{\pi}{4}) & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta_1 & \sin\theta_1 & 0 \\ 0 & -\sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\cos\theta_1 = \frac{\sqrt{2}}{\sqrt{3}}, \sin\theta_1 = \frac{1}{\sqrt{3}}$$

5

7. The figure reading method according to claim 5, wherein at the projection step, a projection plane perpendicular to a change direction of color information other than a direction of  $(R, G, B) = (1, 1, 1)$  is found according to a feature of a light source, and points of extracted main colors are projected onto the projection plane.

10

8. The figure reading method according to claim 6 or 7, wherein at the candidate narrowing down step,

distances between points of main colors on the found projection plane are compared,

15

if a distance is within a predetermined threshold range, then the combination of the main colors is regarded as valid, and

if a distance is outside the predetermined threshold range, then the combination of the main colors is regarded as invalid.

20

9. A figure reading program product embodied on a computer-readable medium and comprising codes that, when executed, cause a computer to perform a method for reading, recognizing and outputting a figure, the method comprising:

an image input step of inputting a color image;

a main color extraction step of extracting main colors contained in the color image and resolving the color image into main color images respectively of the main colors extracted from the input color image;

5 a projection step of projecting points of extracted main colors on a three-dimensional space onto a plane by using a conversion expression;

a candidate narrowing down step of removing combinations that need not be combined according to features of distance between main colors projected onto a two-dimensional space; and

10 a combination generation step of combining images from candidates narrowed down and generating an image area candidate.